MULTI-COMPONENT GOLF CLUB HEAD

FIELD OF THE INVENTION

The present invention relates to a multi-material, multi-component metal wood golf club head.

BACKGROUND OF THE INVENTION

Golf clubs have achieved a remarkable transformation from persimmon wood clubs to the present day metal woods with their extremely large head sizes. This has been made possible by high strength metallic materials, which allow the golf ball to be hit farther and straighter because of increased club head inertia and coefficient of restitution.

Particularly, development of titanium alloys, which are light (specific gravity: 4.5 to 5.0) and strong, have allowed significant increases in the head size and subsequent practical shaft length of a golf club. Specifically, a large moment of inertia, resulting in an increased area of high speed on the club face can be achieved by use of a large club head. Thus there is a constant demand for club heads of greater size. However, enlarging the club head also increases its weight. Most of the metal wood golf clubs manufactured today have a shell thickness so thin that they border on practical manufacturing limits. This has resulted in the search for materials that are even less dense than titanium. Golf club manufacturers are looking for solutions wherein lighter and stronger materials may be employed. And, in some cases, for materials that will partially replace titanium, which is relatively costly and requires considerable care in forming and casting.

Among the more prominent considerations in club head design are loft, lie, face angle, horizontal face bulge, vertical face roll, center of gravity, inertia, material selection, and overall head weight. While this basic set of criteria is generally the focus of golf club engineering, several other design aspects must also be addressed. The interior design of the club head may be made to achieve particular performance

characteristics, such as with the inclusion of hosel or shaft attachment means, or the use of weight members.

The United States Golf Association (USGA), the governing body for the rules of golf in the United States, has specifications for the performance of golf clubs and golf balls. Golf clubs are limited to a Coefficient of Restitution (COR) of 0.83. One USGA rule limits the golf ball's initial velocity after a prescribed impact to 250 feet per second $\pm$ 2% (or 255 feet per second maximum initial velocity). To achieve greater golf ball travel distance, ball velocity after impact and the coefficient of restitution of the ball-club impact must be maximized while remaining within the rules.

SUMMARY OF THE INVENTION

The present invention relates to a multi-material, multi-component metal wood golf club head comprised of a front face having a geometric face center, wherein the center of gravity is at least 6 mm lower than the geometric face center, and the point of maximum Coefficient of Restitution (COR) is not lower than 2 mm below the geometric face center.

An embodiment of the invention, designated as club head, comprises a first body portion, a second body portion, and a hosel member. The first body portion comprises a cup-like face section, a sole section, and a bore-thru hosel tube. The second body portion comprises at least a crown section and a substantial portion of a skirt section, and is of a lower density than the first body portion. The density of the second body portion may be between about 0.1 g/cc to 4.0 g/cc.

The material of construction for the first body portion may be a stainless steel alloy, but preferably is a titanium alloy. While magnesium is preferred for the second body portion, composite, or other lightweight metal such as aluminum, or a thermoplastic may be substituted for the magnesium, but with different performance characteristics. The third body portion is a hosel section formed from a lightweight metal or a thermoplastic, including nylon, composite or aluminum materials.

The club head of the present invention has a coefficient of restitution (COR) greater than 0.80, with a COR gradient created in the front face. The thickness of the

face is preferably progressively greater in a direction from the crown section to the sole section. This is a beneficial design consideration, since the club head has a lowered center of gravity, the greater face thickness at the sole section refocuses the COR towards the center of the face.

The weight reduction, due to the use of lower density materials in the second body portion and hosel member, allows for that weight to be relocated in the club head. The present invention provides for a weight member, having a generally horseshoe shape, to be positioned on the inside surface of the sole section, at a point near the sole/skirt junction. This further lowers the club head center of gravity and moves it farther from the face, and preferably at least 12 mm from the centerline of the shaft axis.

Another embodiment of the invention utilizes only two body portions, the light weight second portion incorporating both the crown section and the hosel member

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front schematic of a golf club with the face square and the club head soled in the address position for depicting the face center and center of gravity based on test data.

FIG. 2 is a top schematic of FIG. 1.

FIG. 3 is an expanded pictorial view of an embodiment of the invention, having three body portions.

FIG. 4 is a top view of FIG 3 thereof.

FIG. 5 is a cut out top view taken along line A—A of Fig. 8.

FIG. 6 is a partial cross-sectional view showing the bore-thru hosel tube and weight member.

FIG. 7 is a toe view of Fig. 3 thereof.

FIG. 8 is a front view of Fig. 3 thereof.

FIG. 9 is an expanded pictorial view of another embodiment of the invention. having two body portions.

FIG. 10 is a top view of FIG 9 thereof.

FIG. 11 is a toe view of FIG. 9 thereof.

FIG. 12 is a front view of FIG. 9 thereof

FIG. 13a is a side view of the variable thickness front face of the present invention.

FIG. 13b is a side view of the variable thickness front face of an alternate embodiment.

FIG. 14 is a graph illustrating the relationship of launch angles to the face center for the prior art Titleist® 983K driver.

FIG, 15 is a graph illustrating the relationship of launch angles to the front face for the present invention.

FIG. 16 is a graph depicting the relationship of backspin to the front face for the prior art Titleist® 983 K.

FIG. 17 is a graph depicting the relationship of backspin to the front face for the present invention.

FIG. 18 is a graph relating ball speed to front face for the prior art 983K.

FIG. 19 is a graph relating ball speed to front face for the present invention.

FIG. 20 is a graph showing ball distance at positions on the front face of the prior art 983K.

FIG. 21 is a graph showing ball distance at positions on the front face of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The golf club head according to preferred embodiments of the present invention, is a multi-material and multi-component hollow club head.

As shown is FIGS. 3-8, a club head **30** is generally composed of three components, which includes a first body portion **31**, a second body portion **32** and a hosel member **33**. First body portion **31** is substantially comprised of: a cup-shaped front face section **37**; a sole section **36** that includes a horseshoe shaped high density weight member **40** that is positioned on the inner surface of the sole section **36** at a predetermined distance from the front face section **37**; and, a bore-thru-hosel

tube **42**. Second body portion **32** is of a lower density than the first body portion **31** and comprises at least a crown section **34**, and a substantial portion of a skirt section **35**. Hosel member **33** is also of a low density material having one end **45** for connection to a shaft (not shown) and the opposing end **46** for connection to the bore-thru-hosel tube **42**.

The density range for second body portion **32** and hosel member **33**, is from about 0.1 g/cc to 4.0 g/cc. Both may be formed from materials such as aluminum, graphite composite, a thermoplastic, but the preferred material for the second body portion **32** is magnesium, and the preferred material for the hosel member **33** is nylon. The method of manufacturing the portions **32** and **33**, may be casting, injection molded, machining, prepreg sheet formed, and the like. Preferably, the second body portion **32** has a thickness in the range of about 0.5 mm to about 1.5 mm, and more preferably less than about 1.0 mm. An advantage of injection molding is that it may provide the second body portion **32** with a geometrically complex shape that includes the crown section **34** and a substantial part of the skirt section **35**.

The materials for forming first body portion **31** may be stainless steel, pure titanium or a titanium alloy. The more preferred material comprises titanium alloys, such as titanium 6-4 alloy, which comprises 6% aluminum and 4% vanadium, or SP-700 titanium alloy, which comprises 4.7% aluminum, 2.9% vanadium, 2.0% molybdenum and 2.1% iron and is commercially available from NKK (Japan) and RTI International Metals (Niles, Ohio). First body portion **31** may be manufactured through casting with a face insert that is made by forming, or forging with a stamped sole, or forming a wrapped face with a stamped sole, or powdered metal forming, or metal-injection-molding and the like.

By using magnesium for the second body portion **32**, a certain amount of weight may be reassigned to the weight member **40**, which is integral with the sole section **36**. The horseshoe shaped weight member **40** has a specified density is the range from about 4 g/cc to 20 g/cc, and may be selected from such materials as tungsten, molybdenum or another like metal in a like density range. Weight member **40** may be cast, injection molded, machined or formed by a powdered metal process. Weight member **40** is positioned away from the face section **37**, a critical design

concept for the lowering of the center of gravity **C**. The methods for determining the positioning of the center of gravity **C** and the calculation of the geometric face center **X** are shown on schematic Figs. 1 and 2. Dimensions were measured with the club head face square and the club soled in the address position.

Three embodiments of the club head **30** design of the present invention were tested against a prior art club (Titleist® 983K driver) which is very similar in appearance, size and shape of the embodiments of the present invention. The three embodiments were all generally identical to each other except for the materials of construction of the second and third body portions **32**, **33**.

Test results for determining the position of the center of gravity **C** as it relates to the geometric face center are presented below in Table I, for three different embodiments of the present invention. Test data is also presented for the prior art club head Titleist® 983K, for comparison purposes.

TABLE I (Clubhead Mass Properties)

From Figs. 1 & 2	Titleist®983K (mm)	Embodiment A (mm)	Embodiment B (mm)	Embodiment C (mm)
CG-Xfc	4.37	-2.05	-0.4	-0.88
CG-Yfc	2.29	-7.88	-6.61	-8.19
CG-Zfc	31.89	31.08	30.30	31.12
CG-B	35.76	31.44	32.30	31.34
CG-C	-15.47	-15.26	-14.92	-14.86
FC-X	-27.79	-21.18	-23.27	-22.59
FC-Y	27.29	29.85	29.46	29.59
FC-Z	16.42	15.82	15.38	16.27
MOI IMPACTS	(kg-mm^2)	(kg-mm^2)	(kg-mm^2)	(kg-mm^2)
High-low – x	231.2	217.6	225.2	218.9
Heel-toe – y	358.6	370.3	414.5	355.7
Lofted – z	351.3	255.4	293.0	251.9
About shaft	653.9	563.5	582.3	557.9

(a) Embodiment A comprises magnesium second body portion **32** and a nylon hosel member **33**.

(b) Embodiment B comprises a composite second body portion **32** and an aluminum hosel member **33**.

(c) Embodiment C comprises a composite second body portion **32** and a nylon hosel member **33**.

Embodiment A of the present invention provides for a shift in the center of gravity **C** to a position at least 6 mm below the geometric face center **X**. The actual test results show the center of gravity **C** to be 7.88 mm below its geometric face center **X**, while tests for the Titleist®983K (having a titanium crown and skirt) provided data indicating that the 983K's center of gravity was 2.29 mm above its geometric face center. Comparable shifts in the center of gravity **C** are seen in the test data for embodiments B and C.

The Titleist® 983K has a volume of 363 cubic centimeters, and a titanium SP700 stamped hitting face with a thickness of about 0.122 inch. Unlike the present invention, the 983K does not have a thickness gradient in the hitting face **48** (discussed below). And, while the second body portion **32** of the present invention is formed from magnesium, and the hosel member **33** is formed of nylon, these portions of the 983K are formed from the heavier titanium alloys. Other than these differences, the embodiments of the present invention and the 983K are very comparable in size and dimension. Test results are shown in FIGS.14-21.

FIGS. 14 and 15, depict data indicating launch angles of the prior art Titleist®983K and Embodiment A (with the magnesium second body portion **32**) respectively. The low center of gravity **C**, of Embodiment A, creates a launch angle of about 1.5° higher than that achieved with the prior art 983K club head (13° versus 11.5°).

FIGS. 16 graphically details the spin rate performance of the prior art 983K club head versus the magnesium crown of Embodiment A, as shown in FIG. 17. At the geometric face center of each club head (shown as 0.00 on the **X-Y** coordinates), the present invention produces a backspin of almost 500 rpm lower than the prior art 983K.

A significant improvement in ball speed of the present invention over the prior art 983K can be best described by FIGS. 18 and 19. The maximum ball speed of the prior art club head is achieved at a position about 0.20 inches above the geometric face center (FIG. 18) while the maximum ball speed of the magnesium crown present invention is maintained at about the geometric center or lower. This point of maximum ball speed is the point of maximum coefficient of restitution, which is often referred to by golfers as the "sweet spot".

The final results are culminated in FIGS. 20 and 21. With data taken at the geometric center for both club heads, FIG. 21 shows the club head of the present invention achieving an increase of almost 7.5 yards over that of the prior art.

These figures depict the initial ball speeds when the clubs traveling at about 110 mph impact Titleist PRO V1 balls. The angle of attack is about 2°, and the effective loft angle is about 12°. The clubs are mounted on a robot, which is driven to impact the balls at the desired club speed. Robots are commercially available from the True Temper Corporation or the Wilson® Sporting Goods Co. The locations of ball impacts are distributed over a rectangular area of 0.50 inch in the vertical direction and about 1.0 inch in the horizontal direction. The mechanical driver has the ability to repeatedly hit the balls at any desirable location on the hitting face. The ball speeds are measured by launch monitors. Any suitable launch monitors can be used. Examples of launch monitors include those described in commonly owned United States patent numbers 6,533,674, 6,500,073, 6,488,591, 6,285,445, 6,241,622, 5,803,823 and 5,471,383, among others.

Preferably, the front face section **37** of the present invention has a gradient thickness in the hitting face **48** ranging from the thinnest thickness about the crown section **34** to the thickest at the sole section **36**. FIG. 13a depicts the preferred front face section **37**, as including a machined face insert, and wherein T_1, of the upper portion near the crown section **34** can be as thin as about 0.08 inch (2.03 mm), the thickness T_2, at the middle section is about 3 mm, and the lower portion nearer to the sole section **36** has a thickness T_3 of about 0.20 inch (5.0 mm). This thickening of the lower region of the hitting face **48** causes an upward shift of the point of maximum coefficient of restitution (COR) to a position not lower than 2 mm below the

geometric face center **X** and preferably about equal to the face center **X**. The club head **30** has a COR of at least 0.80 under test conditions, such as those specified by the USGA.

An alternate embodiment for the front face section **37** is shown in FIG. 7b, wherein the face insert is of a constant thickness in the $\mathbf{T_2}$ area and varied $\mathbf{T_1}$ and $\mathbf{T_3}$ areas, with the thinnest thickness at the crown area. Not shown is another alternative front face section wherein the insert area thickness $\mathbf{T_2}$ is varied and the thickness of sections depicted by $\mathbf{T_1}$ and $\mathbf{T_3}$ are constant.

The standard USGA conditions for measuring the coefficient of restitution is set forth in the *USGA Procedure for measuring the Velocity Ration of a Club Head for Conformance to Rule 4-1e, Appendix II. Revision I, August 4, 1998 and Revision 0, July 6, 1998,* available from the USGA. Such tests measure COR by measuring ball resiliency. COR is the ratio of the velocity of separation to the velocity of approach. In this model, therefore, COR was determined using the following formula:

$$(v_{club\text{-}post} - v_{ball\text{-}post})/(v_{ball\text{-}pre} - v_{club\text{-}pre})$$

where, $v_{club\text{-}post}$ represents the velocity of the club after impact;

$v_{ball\text{-}post}$ represents the velocity of the ball after impact;

$v_{club\text{-}pre}$ represents the velocity of the club before impact (a value of zero for USGA COR conditions); and

$v_{ball\text{-}post}$ represents the velocity of the ball before impact.

The COR, in general, depends on the shape and material properties of the colliding bodies. A perfectly elastic impact has a COR of one (1.0), indicating that no energy is lost, while a perfectly inelastic or perfectly plastic impact has a COR of zero (0.0), indicating that the colliding bodies did not separate after impact resulting in a maximum loss of energy. Consequently, high COR values are indicative of greater ball velocity and distance.

First and second body portions, **31**, **32** and hosel member **33**, are sized and dimensioned to be attached together by any conventional methods used to join dissimilar materials, such as brazing and structural adhesives. A high quality plasma

welding technique, similar to the welding technique used in Titleist® 983 driver club, is preferred.

An alternate embodiment, depicted by FIGS. 9-12, and referred to as club head **50**, illustrates the advantage of injection molding the second body portion, wherein a hosel section **51** and bore-thru-hosel tube **52** are integrated with a crown section **53** to form a crown portion **54**. The advantage is that even more of the "high section" of the club head is made from a low density material (compared to the club head of embodiment **30** where bore-thru is made of higher density material). This allows for further lowering of the center of gravity C. The challenge is that the hosel is typically less rigid when made of low density material. Conventional golf clubs typically include a hosel welded on to the body of the club, which requires more manufacturing time and increases the complexity of manufacturing.

Alternatively, the club head of the present invention may also be used with the smaller fairway woods, which can have volume as low as about 150 cubic centimeters. Preferably, the mass of the inventive club head is greater than 150 grams but less than 300 grams. It is anticipated that a fairway wood may be made from the design concepts of the present invention. Such a wood may have a first body portion made of a metal such as stainless steel, a second body portion (substantially the crown and skirt) made from a lower density metal such as titanium, and a hosel member having a density no greater than the second body portion.

While various descriptions of the present invention are described above, it should be understood that the various features of each embodiment could be used alone or in any combination thereof. Therefore, this invention is not to be limited to only the specifically preferred embodiments depicted herein. Further, it should be understood that variations and modifications within the spirit and scope of the invention might occur to those skilled in the art to which the invention pertains. The scope of the present invention is accordingly defined as set forth in the appended claims.